SAGE III Ozone Loss and Validation Experiment

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The SAGE III Ozone Loss and Validation Experiment (SOLVE) campaign is cosponsored by the NASA Upper Atmosphere Research Program, the Atmospheric Effects of Aviation Project, the Atmospheric Chemistry Modeling and Analysis Program, the Earth Observing System Validation Program, and the European Science Commission. It is the largest field experiment ever conducted to examine stratospheric ozone levels over the Arctic region. The mission will be conducted during the 1999–2000 winter from Kiruna, Sweden, and will employ multiple aircraft, balloons, ground-based instruments, satellites, and an extensive theory team to examine the processes that control polar to midlatitude stratospheric ozone levels. The experiment will acquire correlative measurements needed to validate the Stratospheric Aerosol and Gas Experiment (SAGE) III satellite to help quantitatively assess high-latitude ozone loss. The results of the SOLVE campaign will both expand the understanding of polar ozone processes and provide greater confidence in current ozone monitoring capabilities.

Managed by the Earth Science Project Office at Ames Research Center, the SOLVE campaign includes over 350 scientists, engineers, and technicians from many NASA centers, other Government agencies, and universities across the world. More information, including the experiment overview, goals, schedule, instrument payloads, mission details, and science team members, can be found at the SOLVE Web page (http://cloud1.arc.nasa.gov/solve).

The first part of the SOLVE campaign began in November, 1999, with launches of in situ and remote stratospheric balloon payloads. These launches, just prior to the appearance of cold stratospheric temperatures below 195 K, enabled the experiment to obtain samples of the polar vortex in its initial condition prior to the appearance of polar stratospheric clouds (PSCs). These observations were important for interpreting the subsequent cold temperature chemistry and ozone loss later in the experiment.

The NASA DC-8 began its first deployment on December 1, 1999. The objective was to obtain remote measurements of the initial states for ozone (O_3), reactive nitrogen (NO_y), reactive chlorine (Cl_y) compounds, aerosols, and the nitric acid (HNO_3) and water (H_2O) vapors that will eventually condense to form PSCs. The DC-8, however, observed colder than normal temperatures in the early vortex lifetime, and observed Type-1a PSCs on several flights. Including the transits, the DC-8 had a total of eight successful flights and made the first coordinated science flight over Russia.

Jim Anderson (Harvard University), Paul Newman and Mark Schoeberl (NASA Goddard Space Flight Center), and Owen B. Toon (University of Colorado) collaborated in this research.

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Stratospheric Tracer-Field Measurements with a New Lightweight Instrument: The Argus Spectrometer

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Argus is a new, lightweight spectrometer designed for measuring the stratospheric nitrous oxide (N_2O) and methane (CH_4) tracer fields in situ from balloons and aircraft. It is a second-generation instrument drawing on the experience gained with the very successful Atmospheric Laboratory for Applications and Science (ATLAS) instrument measuring N_2O and flying on the NASA ER-2 since 1986.

During the past several years Argus was part of the Observations from the Middle Stratosphere (OMS) balloon payload probing the tropical and mid-latitude stratosphere in studies of transport issues related to dispersion of aircraft exhaust. A major concern motivating these studies was the potential for nitrogen oxides (NO_x) generated in the exhaust plume of a supersonic high flyer to reach the tropical ozone production region by rapid transport from a midlatitude flight corridor. NO_x is effective in destroying ozone (O_3) in a well-known catalytic cycle that can proceed rapidly under stratospheric photochemical conditions.

Several results from research carried out with the Argus instrument are described below.

Tracer Laminae in the Tropics – Transport of air from the midlatitudes into the tropics in the stratosphere is known to be inhibited by a "transport barrier." The existence of such a barrier was already well known from satellite studies of dispersion of the Mt. Pinatubo aerosol cloud, following Pinatubo's eruption in June, 1991. On the other hand, some transport of stratospheric air into the tropics is known to occur from the detailed study of tracer mean vertical profiles in the tropics. Interest in this issue centers on the fate of aircraft exhaust products injected into the midlatitude stratosphere, and their potential impact on the tropical ozone production region.

During an OMS balloon launch from 7° S in Brazil in November, 1997, thin laminar regions of low N_2O on the normal tropical profile of this tracer were observed. (N_2O is lower in the midlatitude stratosphere than in the tropics at the same altitude.) The data indicated clearly midlatitude values of N_2O in the tropics. This appears to be a direct observation of the process of rapid transport into the tropics of midlatitude stratospheric air masses. The observations suggest that this transport is episodic, possibly the result of breaking of midlatitude stratospheric waves (Rossby waves).

Long-Lived Arctic Winter Vortex Remnant – During an OMS balloon launch (in conjunction with ER-2 flights) from Fairbanks, Alaska, in late June, 1997, several layers of unusually low values in the N_2O and CH_4 tracer fields were encountered. These were clearly "remains" of the winter polar vortex with the observed filaments preserving very low tracer values characteristic of the interior of the vortex which had subsided from higher altitudes during the previous winter. The unusual, possibly unique, quality of the discovery was that these layers had maintained their integrity for about two months, from the time of vortex breakup sometime in late April until their observation in late June.

Intercomparison Flights with ATLAS and Other Tracer Instruments – Plans to design a new ER-2 instrument or to fly Argus on the ER-2, in both cases for the purpose of replacing the older and heavier ATLAS instrument, has motivated two separate flight intercomparison campaigns. In the fall of 1998, Argus and ATLAS flew together on the ER-2 in an otherwise unrelated atmospheric radiation campaign called CiRex (Cirrus Radiation Experiment). In the fall of 1999, a comparison of several N_2O instruments was carried out in preparation for the SOLVE (SAGE II Ozone Loss and Validation Experiment) Arctic Ozone mission to take place in January through March of 2000.

Both of these intercomparison campaigns provided an opportunity to pass the pedigree of N_2O tracer field measurements made by ATLAS, and widely accepted as a standard in the ER-2 airborne measurement community, on to the new Argus instrument. The importance of this transfer is the significant weight reduction realized by the dual channel Argus instrument, thus allowing space for additional payload in the wide-ranging ER-2 atmospheric chemistry payload suite.

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TRMM/ Large-Scale Biosphere Atmosphere Experiment in Amazonia (LBA)

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The TRMM/LBA mission was conducted in January and February, 1999, from several sites in the lower Amazonian region of Brazil. TRMM is the Tropical Rainfall Measuring Mission satellite. The experiment was conducted as part of the larger umbrella mission, Large-Scale Biosphere/Atmosphere Experiment in Amazonia (LBA). TRMM/LBA was one in a series of global field experiments that were planned to obtain ground validation measurements in support of the TRMM satellite mission. The objective of the field campaign was to obtain measurements for a tropical continental site, which would provide for the validation of the physical assumptions required